Computers, Environment and Urban Systems xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Computers, Environment and Urban Systems

journal homepage: www.elsevier.com/locate/ceus

Editorial

Land use, transport, and environment interactions: WCTR 2016 contributions and future research directions☆

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ARTICLE INFO

Keywords:
LUTI
Land use
Transportation
Urban models

ABSTRACT

Research on the interaction amongst land use, transport, and the environment has a long history and can fill volumes of publications. Such research has contributed to urban and transportation planning and substantially reduced problems in transport, land use, and the environment. However, solving traditional problems caused by the spatial disorder of land use and transportation facilities still remains an elusive goal. For instance, we can easily find that severe traffic jams and high car dependencies cause various problems in many developed cities, while extensive suburbanization driven by high mobility has led to increased energy consumption and environmental impact. Similar problems have emerged in developing countries with a greater magnitude than in developed nations. Additionally, new problems related to sustainability, including social exclusion and climate change, are in effect around the world. The progress and emergence of new technologies in transportation, the potential of travel behavior monitoring, and the sensing of the earth surface are motivating the expansion of research topics and methodologies. The World Conference on Transport Research Society (WCTRS) is one of the oldest research communities studying land use/transport interactions. This virtual special issue consists of selected and fully reviewed papers presented at the 2016 World Conference on Transport Research (WCTR) in Shanghai. In this editorial, we place these published contributions and others made during the conference in the context of the broader literature, present an assessment of the progress of research in this domain, and finally propose an agenda for future research directions in the field of transport, land use, and environmental interactions.

1. Introduction

The World Conference on Transportation Research (WCTR) has been held every three years since the first conference in Rotterdam in 1977. The 14th WCTR was held in Shanghai in July 2016, where 1167 papers were presented in 222 oral presentation and 33 poster sessions (Boltze, Ülengin, & Li, 2017). Focusing on the analysis of interactions between transport, land use, and the environment, the Special Interest Group (SIG) for Transport and Spatial Development was launched in 1988 as the first SIG in WCTRS. This SIG was the successor of International Study Group on Land Use Transport Interaction (ISGLUTI) (Webster et al., 1988; Webster and Dasgupta, 1991), which was a network of international researchers interested in the land use/transport feedback cycle. SIG 1 is now known as SIG F1 and is responsible for organizing the conference's session track on the topic of spatial development in transport research. At WCTR 2016, 32 papers were presented in nine sessions organized by SIG F1. Several of these papers were selected as candidates for publication and reviewed in the Computers, Environment and Urban Systems (CEUS) editorial system. Through the review process, three papers were accepted and added to this VSI. In addition to these three papers, 15 papers were published in the Transportation Research Procedia No. 25, which went online in 2017. In this section, we provide an overview of the topics presented in the SIG F1 sessions at WCTR 2016, as they represent a cross-section of the breadth of research themes that have become central to the research agenda of scholars active in the study of interactions between land use and transport.

The topics and methods applied in SIG F1 research covered a broad spectrum. The topics presented at the conference included the analysis of various modes of transport (Pareekh, Mitra, & Majumdar, 2017),

☆ Virtual special issue (VSI) for WCTR Shanghai conference

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https://doi.org/10.1016/j.compenvurbsys.2019.04.002
Received 8 April 2019; Accepted 10 April 2019
0198-9715/ © 2019 Published by Elsevier Ltd.

Please cite this article as: Masanobu Kii, Rolf Moeckel and Jean-Claude Thill, Computers, Environment and Urban Systems, https://doi.org/10.1016/j.compenvurbsys.2019.04.002

public transport and security (Di, 2017), travel behavior and spatial interaction (Dhulipala, Kedia, Salini, & Katti, 2017; Oszter, 2017), impact of urban transport on energy and greenhouse gas emissions (Inturri, Ignaccolo, Pira, Caprì, & Giuffrida, 2017; Jiang, Gu, Chen, He, & Mao, 2017; Khan, Fatmi, & Habib, 2017), air pollution (André, Carteret, Pasquier, & Liu, 2017; Hu & Li, 2017; Pasquier & André, 2017), land use and transport integration (Capelle, Sturm, Vidard, & Morton, 2017; Lyu, Han, & Vries, 2017; Noviandi, Pradono, Tasrif, & Kusumantoro, 2017), impact assessment of transit on spatial development (Nakamura, Morita, Vichiensan, Togawa, & Hayashi, 2017; Sohoni, Thomas, & Rao, 2017), and land use analysis at the metropolitan (Gao, Kii, Nonomura, & Nakamura, 2017) and global levels (Kii & Nakamura, 2017).

The analytical approaches were equally varied as the substantive themes of research. They can roughly be classified into three classes: generalized linear models (GLM), transportation and related models, and others approaches. The first class included a combination of travel behavior models and statistical models (Inturri et al., 2017; Jiang et al., 2017; Sohoni et al., 2017), statistical models for air pollution analysis (Pasquier & André, 2017), suitability models for land cover estimation (Kii & Nakamura, 2017), spatial multiple regression and autocorrelation analysis (Di, 2017), and non-linear regression analysis (Oszter, 2017). The second class encompassed neuro-fuzzy based route choice models (Dhulipala et al., 2017), combination of traffic models with vehicle emission models (André et al., 2017), systems dynamics (Noviandi et al., 2017), and latent class modeling for alternative fuel vehicle choice (Khan et al., 2017). Finally, the third class included urban economic models (Gao et al., 2017), a bottom-up analysis of quality of life indicators (Nakamura et al., 2017), rule-based population, land use and road infrastructure scenario generator (Lyu et al., 2017), factor analysis for city type classification (Pareekh et al., 2017), and descriptive statistics for particulate matter emissions from vehicles and its exposure to people (Hu & Li, 2017). The three papers published in this virtual special issue are summarized below in more detail.

Jiang et al. (2017) analyzed the effects of the spatial form of neighborhoods and streets on household travel energy consumption and CO2 emissions using a logit model specified and calibrated for Jinan, China. The model was simple but operational, and may also be suitable to sketch planning measures and processes that contribute towards achieving a low carbon society. The key point of this study was to quantify the various spatial urban forms using nine indicators for neighborhoods and twelve indicators for streets. For example, it was found that a higher land-use density and adequate street design discourage the use of private automobiles. Conversely, lower street density, larger land parcel size, lower job-housing balance, and less mixed land use encourage longer car travel. Their results confirmed that the spatial form of neighborhoods and streets affected travel behavior, and consequently, energy consumption and the production of CO2 emission.

Capelle et al. (2017) proposed a new calibration method for the TRANUS integrated land-use and transport model. Despite the long history of Land Use and Transportation Integrated (LUTI) research, calibration methods have not been standardized yet. The authors defined a cost function that represents the deviation between model estimation and observation, and applied an optimization technique to determine the parameters that minimize this cost. A key feature of their approach is the avoidance of high computational cost of calibration by partially fixing the observed production and price variables. The method was applied to the estimation of the shadow prices and substitution parameters taking the case of North Carolina. Thus, the study demonstrated that this method leads to stable convergence.

Gao et al. (2017) applied a monocentric urban economic model to analyze urban performance indices such as the commuting distance, housing floor area, and disposable time, under population and economic growth from 2003 to 2013 in three Chinese cities. By incorporating remote sensing and aggregated socioeconomic data, the model predicted meaningful temporal index trends for these cities. Moreover, this study is a very good example of quantitative urban analysis when limited data are available. This is a desirable feature for analytical tools, particularly in developing countries where spatial statistical data is often in short supply.

All three papers are concerned with spatial modeling. Capelle et al. (2017) investigated a model calibration method. The studies by Jiang et al. (2017) and Gao et al. (2017) investigated the application of a modeling method to spatial analysis. The former study used a discrete choice model, while the latter ones applied an urban economic model. Various types of spatial datasets have been used for model calibration and validation. Capelle et al. (2017) used synthesized spatial data, such as the floor space consumption and housing expenditure. Gao et al. (2017) combined aggregated metropolitan level statistics and remote sensing data to investigate the marginal distribution of the model's output. Jiang et al. (2017) used the building's polygons and street network's polylines to generate the spatial form indices for an urban district. These studies combined the research fields of transportation planning, geography, regional science, urban economics, and spatial statistics.

Amongst the papers presented at the WCTR 2016, the modeling approach was important for the papers selected in this CEUS virtual special issue, owing to the explicit formulation of the analysis assumptions and their validation based on observational evidence. Thus, compliance with the scientific method is achieved and experimental knowledge can be incorporated to develop causal hypotheses that ascertains rigorous investigation. The other studies presented at the conference did not necessarily adopt a modeling approach. As mentioned above, some of these studies utilized descriptive statistics, while others were based on qualitative or conceptual considerations. While these approaches meaningfully contribute to the broader knowledge in land use and transport, they are often reflective of research at an earlier stage of development. Some papers were practical in nature, which is also regarded as an important category in the WCTR because such papers can provide important baseline information and best practices on current land use, transport, and environmental integration for various regions around the world.

2. State of the art and future directions

A number of surveys of the scholarship of land use and transport interaction (LUTI) modeling can be found in the literature (Acheampong & Silva, 2015; Batty, 2013; Echenique, 2004; Huang, Parker, Filatova, & Sun, 2014; Moeckel, Llorca, Moreno, & Okrah, 2018; Wegener, 2004; White, Engelen, & Uljee, 2015). Currently, the development trends of LUTI models can be traced from the aggregate to the disaggregate level, and from static (or cross-sectional) to dynamic (or longitudinal). This means that these models are evolving towards finer granularity (the household, the firm, the land parcel, or the neighborhood) and are becoming more complex in this process. Not only the mutual dependencies between land use and transportation are modeled, but also, household activities, business decisions, modal choices, household and business demographics, and others, can be explicitly represented through mathematical or numerical modeling. However, as the models become more advanced, estimation and calibration faces greater challenges both with regard to the techniques and to the scope of datasets, while validation still remains a matter of considerable debate when various models are integrated to form multi-layered modeling systems capable of generating a range of possible urban futures. The calibration of LUTI models remains a research issue in search of further enhancements. For instance, TRANUS is an aggregated modeling system built on the principles of spatial interaction, which is static, is more coarse, and explicitly accounts for fewer dimensions or urban systems than micro simulation models (Waddell, Wang, Charlton, & Olsen, 2010), or complex systems models such as agent-based models (Filatova, 2015). Capelle et al. (2017) indicates that these static aggregated models still require further development with regard to their

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calibration methods and techniques. Machine learning approaches have been advocated in this respect as a solution to circumvent the bottleneck that conventional techniques may present, which may be exacerbated when fine-granularity, "big" spatial data are leveraged for a more nuanced depiction of the urban system (Gong & Thill, 2015; Moghadam, Helbich, & Tayyebi, 2017).

Additionally, we must recognize that there still exist theoretical and technological challenges in developing and implementing LUTI models that are multi-scalar and multi-modular. LUTI models were originally conceived as operational urban models that could be implemented to simulate the transformations that urban centers undergo as conditions of the broader socioeconomic and political environment change and as regions go through population fluxes. Coupled with regional economic models (such as regional input-output modeling, computable general equilibrium (CGE) models), they embed the urban environment within the multi-regional economic system, so that vertical and lateral shocks can be studied from the perspectives of micro and macro processes. Thus, LUTI models not only provide a predictive framework for urban planning, but they are also well suited to tease out causal relationships across scales and across decision domains for policy formulation and evaluation. In this respect, incorporating factors related to environmental issues into a LUTI model is regarded as a critical contemporary challenge, particularly with respect to climate policy applications as exemplified by Filatova and Bin (2014), Schindler and Caruso (2014) and others.

Moreover, various studies have attempted to predict long-term global urban activities, including population settlement and land use, to estimate global greenhouse gas emission scenarios (Jones, 2016; Seto, Güneralp, & Hutyra, 2017). Most of these global urbanization studies have used simple growth models or probability models based on the experimental distribution, and did not incorporate the interaction amongst the population growth, land use, housing/office market, and transport technologies. In the papers presented at the WCTR 2016 conference, Kii and Nakamura (2017) attempted to capture the causes of global urbanization using a geographical approach. Gao et al. (2017) proposed a method of capturing the mechanism of urban formation when limited data are available. This study can be positioned at the intersection of urban level modeling and global scale modeling because data that can reduce the need for analysis can also expand the application of the study to more cities around the world. Jiang et al. (2017) have statistically estimated the effect of the spatial form for neighborhoods and street networks on CO2 emissions. Their method requires a detailed building and road network data. Recently, such datasets have been drastically accumulating in many cities (e.g., OpenStreetMap). Thus, in the future, this approach has the potential to be applied to the global impact assessment of urban spatial forms on CO2 emissions longitudinally under various policy scenarios.

In broad terms, we can identify two different directions in the research on land use, transport, and environment interactions: complex, disaggregated, and dynamic modeling approaches, and simple, global, and inter-temporal modeling approaches. Kii, Nakanishi, Nakamura, and Doi (2016) remarked that both of these directions are required in LUTI research, and that co-evolution can be achieved through a transdisciplinary approach. Studies for local complex LUTI models may determine the micro basis of various urban activities, and the essence of factors of urban formation that can be used as the theoretical background for global simple LUTI models. Moreover, global LUTI studies may be able to compare the different impact of various factors on urban formation through the application of models to a selection of cities around the globe. These cities will have a wide range of variation in their socioeconomic development and geographical context. Additionally, global LUTI model studies may clarify the applicability and transferability of local models.

Apart from the modeling considerations discussed so far, it is clear than SIG F1 sessions on land use, transport and environment interactions encompass a wide variety of substantive research topics and approaches. This variety could be a source of concern about the lack of a cohesion in this research field, and possibly the lack of theoretical thread that cuts across the activities of this research group. With this in mind, how can the studies in this session track be connected, and what would be the scientific contribution of such a research group? Although it may sound paradoxical, we believe that this variety is the fountainhead of research value for an integrated investigation of land use, transport, and the environment. Urban activities naturally consist of a wide variety of factors and their intricate relationships. In other words, the comprehension of the total and detailed interactions between urban activities is still an ambitious and somewhat elusive research target. Currently, most studies are focusing on limited aspects of the interaction factors. Essentially, this means that urban studies have a wide research spectrum; therefore, they must integrate various disciplines. The combination and integration of these aspects may open new research frontiers in spatial analysis. Therefore, this session track provides the opportunity to find a connection with related research disciplines that are not limited to individual research fields and approaches. Our objective is for this research group to be used as a forum to produce holistic and transdisciplinary knowledge.

3. Conclusions

In this era of climate change, the cross-cutting theme of land use, transport, and environment interaction is an attractive research subject for urban and transport policy researchers, and spatial analysts. WCTRS SIG F1 is a research group that provides a forum in this field and organizes sessions at the triennial WCTR conference. This virtual special issue consists of papers presented at the WCTR 2016 in Shanghai, and substantially revised through the CEUS review process. The next conference will be held from 26 to 31 May 2019 in Mumbai, India. In future conferences, the following issues could be addressed as research challenges.

1) Filling the gap between academia and practice.
   In addition to academic researchers, the WCTRS also encourages practitioners to participate in the conference. Communication between academics and practitioners will create new value for useful spatial planning and stimulate the next generation of research activities.
2) Integration of knowledge and transdisciplinary approach.
   The LUTI field of study was originally created by fusing transportation engineering and urban economics. Its research topics have been extended from infrastructure planning to a wider range of issues, such as social and environmental policies. The LUTI domain, which affects a wide range of social and environmental issues, should not be investigated only within a closed circle, but rather through a transdisciplinary process.
3) Spatial data development and utilization.

Spatially detailed and long-term human activities, including land use and transport, are now being monitored through various channels. However, access to such data may still be problematic over large territories and for extended time periods. Also, it is typically difficult to use these datasets even for research purposes because human activities are not fully understood holistically and across socio-cultural context, and only hypotheses can be made currently. Further observation of spatio-temporal details is expected to advance spatial research and policy implementation in the area of land-use and transportation interactions, and enable the validation of plausible models across contexts.

Apart from WCTR SIG F1, there are several other forums related to spatial research, such as the World Society for Transport and Land Use Research (WSTLUR), the International Conference on Computers in Urban Planning and Urban Management (CUPUM), the Regional Science Association International (RSAI), and Applied Urban Modeling

(AUM). We strongly believe that cooperation and collaboration amongst these associations and groups will be beneficial to affiliated researchers and will also advance spatial analytic research by joining forces and forming a more interlaced network to advance scholarship in land-use and transportation interactions.

Acknowledgement

This study was supported by JSPS Grants-in-Aid for Scientific Research (KAKENHI) (Grant Numbers 15H02869 and 16KK0013).

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